



MIT SCALE RESEARCH REPORT

The MIT Global Supply Chain and Logistics Excellence (SCALE) Network is an international alliance of leading-edge research and education centers, dedicated to the development and dissemination of global innovation in supply chain and logistics.

The Global SCALE Network allows faculty, researchers, students, and affiliated companies from all six centers around the world to pool their expertise and collaborate on projects that will create supply chain and logistics innovations with global applications.

This reprint is intended to communicate research results of innovative supply chain research completed by faculty, researchers, and students of the Global SCALE Network, thereby contributing to the greater public knowledge about supply chains.

For more information, contact
MIT Global SCALE Network

Postal Address:
Massachusetts Institute of Technology 77
Massachusetts Avenue, Cambridge, MA 02139 (USA)

Location:
Building E40, Room 267
1 Amherst St.

Access:
Tel: +1 617-253-5320
Fax: +1 617-253-4560

Email: scale@mit.edu
Website: scale.mit.edu

Research Report: ZLC-2014-3
Key Factors That Affect the Aftermarket Demand Forecasts
Gevorg Davtyan

For Full Thesis Version Please Contact:

Marta Romero

ZLOG Director

Zaragoza Logistics Center (ZLC) Edificio

Náyade 5, C/Bari 55 – PLAZA 50197

Zaragoza, SPAIN

Email: mromero@zlc.edu.es

Telephone: +34 976 077 605

Key Factors That Affect The Aftermarket Demand Forecasts

By Gevorg Davtyan

Thesis Advisor: Prof. David Gonsalvez, Ph.D.

Summary: The goal of this thesis is to develop a methodology that will help the sponsor company to overcome disadvantages of demand forecasting methods that are based solely on historical data on product demand. In particular the thesis is aimed at identifying key factors that have significant impact on the filtration aftermarket business.



*Master's of Eng. In
Logistics and Supply
Chain Management, MIT-
Zaragoza International
Logistics Program*

*Master's and Bachelor of
Mathematics in the field of
Actuarial Mathematics,
Yerevan State University,
Armenia*

*4 years of experience in
risk management, finance
and banking, Armenia*

KEY INSIGHTS

1. Identify specific factors that can significantly influence demand in the aftermarket business.
2. Quantify the identified factors into indices.
3. Develop a statistical method that describing the statistical relationship between the product demand and the identified factors.

Introduction

Demand forecasting is crucial to any supplier or producer. It helps determine the future levels of production, shipping, and purchases. The accuracy of demand forecasts can make a huge difference in profit and loss. However, the complexity of modern supply chains and highly volatile markets, partly due to globalization and outsourcing, has made forecasting even more difficult.

Though a variety of quantitative demand forecasting methods exist, inaccuracy in demand forecasts is still a challenge for many companies. Quantitative demand forecasting methods, such as time-series forecasting, often share a common shortcoming of using history as the only predictor for the future. The logic supporting this approach is that history repeats itself, which is not always true.

The basic steps of the methodology were to review the existing literature related to different forecasting methodologies (Chopra and Meindl, 2007), principles of factor selection (Armstrong, 1978) and indices for enumerating factors. This was followed by interviews with experts in different business areas and regions to identify the main factors that possibly have an effect on the aftermarket business. As a result of the

initial step in factor identification process, the factors were divided into five main groups: Economic, Industry, Climate/Natural Environment, Commodities, and Political. In addition to global business environment factors, some factors that are specific to the sponsor company were examined: the customers and competitors and the industries they operate in. Thereafter, based on outcome of the factor identification process, various indices issued by different organizations were reviewed for each of the identified factors. The next step of the model was the screening of the factors based on the following factor selection criteria:

1. Is there a strong causal relationship? The strength of the relationship is measured using correlation analysis.
2. Can the relationship be estimated accurately?
3. Will the factor exhibit a substantial change in the forecast period?
4. Can the changes occurring in the forecast period be predicted with fair accuracy?

Although this approach is time consuming as it requires checking each factor separately for all four

criteria, it proved to be useful in other studies (Armstrong, 1968).

After the process of enumerating the factors into indices, a statistical model was developed to generate an equation describing the statistical relationship between the product demand and the identified factors. The factors that satisfy the criteria were incorporated into a regression model to produce a regression equation that describes the relationship between the product demand and selected factors.

The method allows the user to adjust demand forecasting based on indicators that predict events that may have significant impact on the company's product demand and may not be accounted for by quantitative methodologies.

Regression Analysis and Results

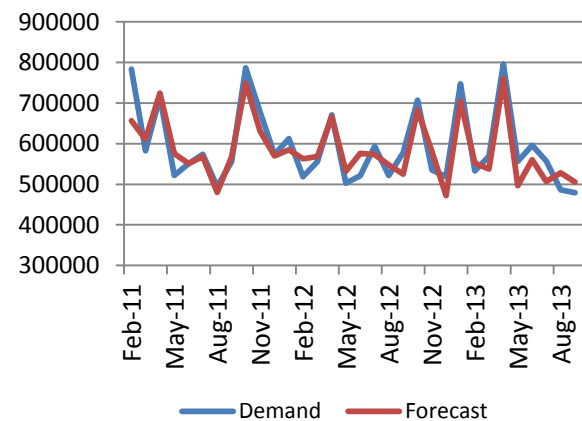
For the beginning several assumptions of multiple regressions that are "robust" to violation were checked: the assumptions of independence of elements of dependent variables, normality of error distribution, linear relationship, and homoscedasticity. Afterwards the following approach was used to select the final list of the factors.

As is known, R^2 increases with the addition of a new term in a model, but R^2 -adjusted increases, whenever the added terms improve the model. Therefore, the concept of R^2 will be used as the indicator of the quality of the regression fit, and R^2 -adjusted along with t-statistics and P-value as criteria of excluding or keeping a factor in the regression analysis.* If any of the factors included in the regression analysis has a P-value level less 5% (which means that it can be stated with a 95% probability of being correct that the variable is having some effect on demand), the factor will be kept. However, if the P-value of any of the factors is greater than 5%, it will be considered for removal based on its effect on R^2 -adjusted. If the exclusion of the factor results in dramatic drop in R^2 -adjusted then it will still remain in the regression analysis.

Following the methodology, regression with high R^2 models were obtained, as seen below.

	Region 1	Region 2
Product 1	87%	87%
Product 2	86%	88%
Product 3	80%	94%
Product 4	86%	88%
Product 5	85%	89%

Here is the graphic illustration of goodness of the model fit to the Product 3 demand in Region 1.



For example, for Product 1 in Region 1, the following factors turned out to be related to the product demand: Agriculture (S&P Agricultural & Fertilizers Index change), Coal (NYSE Arca Coal Index change), S&P 500 (S&P 500 Index change), Marine (Dow Jones U.S. Marine Transportation Index change), Oil (NYSE Arca Oil Index change, and monthly seasonal factors.

Additionally, the sources for factor forecast were provided to the sponsor company to forecast and prevent the impact of unexpected and not repetitive events in the business environment. Here is an example of the historical forecast of Arca Amex Oil Index from 30/01/2013 to 31/01/2014 (Stock Forecasts, www.nextcandle.com). The accuracy of the forecast (12 months) for 2013 was 58%, with lifetime accuracy of 62%.



Conclusions

The methodology was developed to identify as many factors affecting the aftermarket business as possible. This was combined with the statistical

method to deliver the list of final factors that should be used by the sponsor company to adjust the filtration product demand forecast provided by their forecasting software.

For the factor identification process, first, *a priori* analysis was used to create a long list of possible factors that could have any impact on the aftermarket business. Afterward, correlation analysis was performed to understand the direction and the strength of the relationship between the product demand and the factors. The third and the last step of factor identification process was causal regression analysis, which helped to filter and provide the final list of key factors that impact the demand for the products of the sponsor company.

The results obtained proved the goodness of fit for developed methodology. The high explanatory level of the methodology allowed for concluding that the list of the final key factors can provide a powerful tool to monitor the changes in the business environment and to help foresee possible risks and improve the quality of demand forecast.

Additionally, to help the sponsor company to forecast and prevent the impact of unexpected and not repetitive events in the business environment, detailed information was provided about the indices describing the performance of key factors, the source of index forecast, and its accuracy. It is important to highlight that though these forecasts provide a good estimation of future changes in the business environment, in most cases, they cannot predict black swan events.

Cited Sources

Chopra, S. and Meindl, P. *Supply chain management: strategy, planning and operations*, New York: Prentice Hall, 2007, 3rd edition.

Armstrong, J.S. *Long-Range Forecasting: From Crystal Ball to Computer*, Canada: Wiley-Interscience, 1978. 1st edition.

Armstrong, J.S. *Long-Range Forecasting For International Markets: The Use of Causal Models*, New York: Macmillan 1968.

Stock Forecasts, [http://www.nextcandle.com/stock-forecast/\\$XOI/](http://www.nextcandle.com/stock-forecast/$XOI/)